NRL-Contract Monthly Report for May 93

LOW VOLTAGE ELECTRON BEAM LITHOGRAPHY

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The contract has three parts covering aspects of high precision electron beam lithography. (1) Comprehensive computer modeling of the electron beam tool. (2) Experimental determination of the properties of sources, columns, and targets, and (3) The use of silicon single crystals as straightness and orthogonality standards using orientation dependent etching techniques.

Tasks 5-8. Low Voltage Electron Beam Technology

An experiment to test the feasibility of micro lens technology for use with field emission sources has been started. The aim is to produce a simple electrostatic micro lens with sufficient strength to act as a projector lens into a conventional or mini column. This aim is tied to the concept that the effective brightness of a field emission source can be increased by three orders of magnitude by strong focusing in the proximity of the source. The advantage of this for low voltage columns is that less total current is drawn from the source and there is a drop in the energy spread of the source. An additional advantage would would follow from the small total current in the column as space charge effects are reduced.

The last reporting period saw the start of an experiment to produce an aperture lens with micron dimensions. Some structures have been made and tested for breakdown across 1micron of silicon nitride film. These structures reliably produce 100volt plus breakdown voltages under electron bombardment in the SEM. One possible one method of forming an aperture through the lens structure is to use ion beam milling. Figure 1 shows the results of milling using a 0.2micron Ga ion beam. The aperture is etched through 200nm of Al and 1micron of silicon nitride into the silicon substrate. The "notch" in the aperture is due to pattern generator which wrote a spiral pattern.

Figure 2 shows the formation of a self aligned cone in the aperture by using a annular pattern. This cone is nitride and therefore not a field emitter. The aperture causes an asymmetry in the breakdown characteristics of the film. The breakdown tests were performed in the SEM under electron bombardment. With the top Al surface positive w.r.t the Si substrate the breakdown voltage is 30volts compared with 100volts for a negative Al surface. The positive voltage also produces migration of material through the aperture, figure 3.

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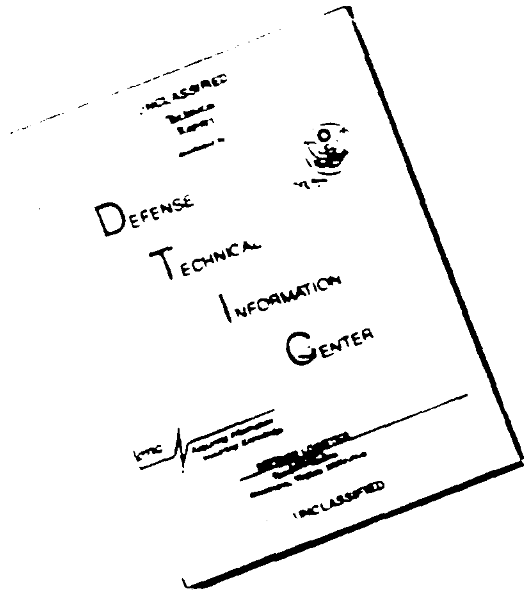

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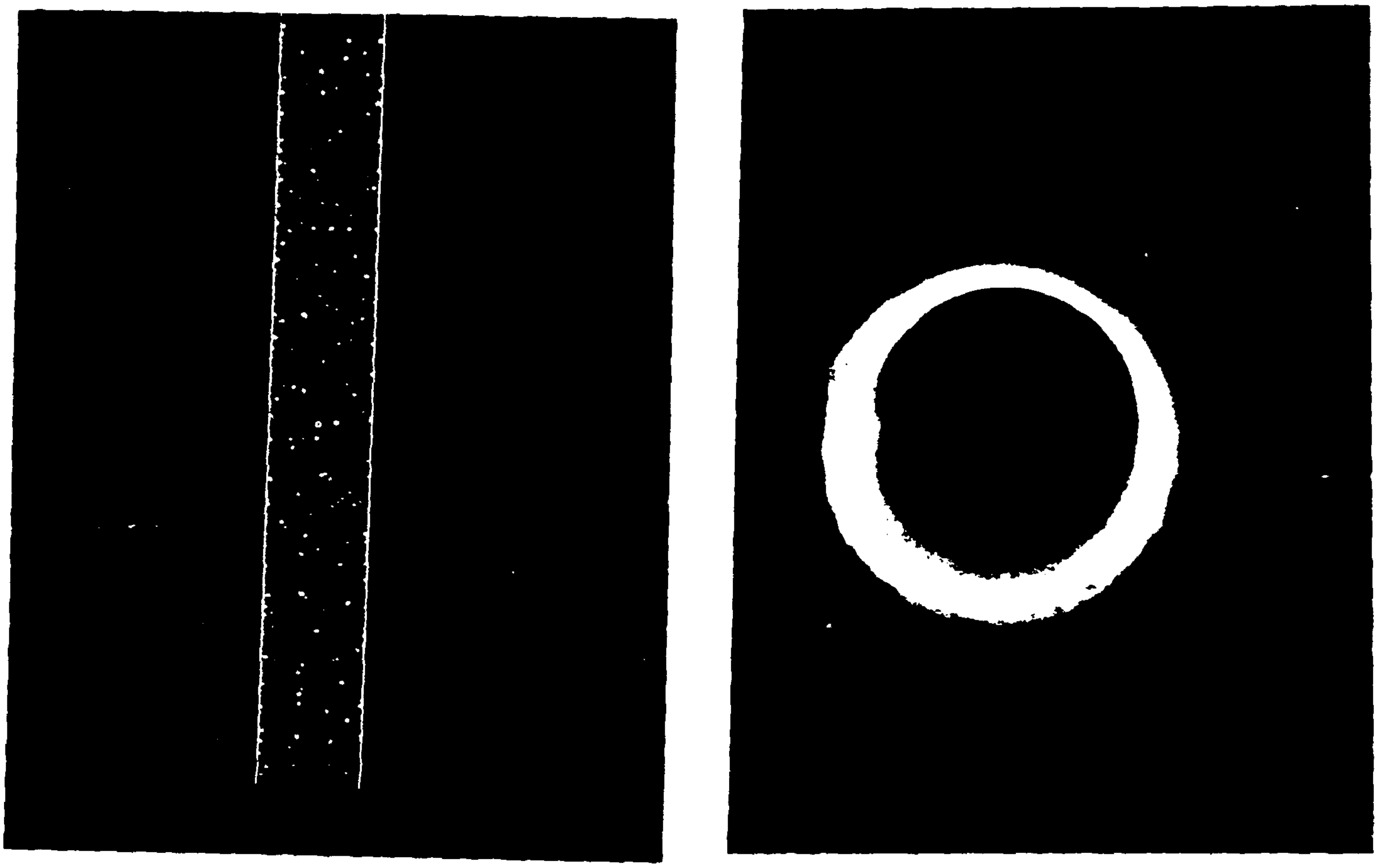
The self aligned cone structure of figure 2 was coated with 50nm of Au, figure 3a. The results were similar for the simple aperture. A negative top surface bias gave a good 120volt breakdown figure, but a positive bias caused migration of material. Figure 3b and c. Also there was considerable emission of electrons from the aperture as evidenced by the SEM detector being saturated. It is possible that much of the material is displaced by the combined effects of heat and field, figure 3c was obtained after 20mins at 50volts and 20mA (0.1watt).

Anticipated Work in the next reporting period.

Additional exposures of the Si standard artifact will be undertaken. Additional calculations of electron scattering properties will be performed.



Ion milled aperture in 200nm Al
and 1μ of silicon nitride.

FIG 1.

Self aligned cone in ion milled aperture.

FIG 2.

a)

c)

b)

a) Au coated self aligned cone.
b) after 10 mins +50 volts 20mA
c) after 20 mins +50 volts 20mA.
FIG. 3.